Environmental Assessment
Sea Turtle Bycatch Reduction Research Activities at the Pacific Islands Fisheries Science Center

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Summary

The purpose of this Environmental Assessment (EA) is for the National Marine Fisheries Service (NMFS) to consider the potential environmental impacts of specific marine turtle research activities conducted by the Fishery Bycatch and Stock Assessment Division at the Pacific Islands Fisheries Science Center (PIFSC). This EA fulfills the requirements of the National Environmental Policy Act (NEPA) and the National Oceanic and Atmospheric Administration's (NOAA) Administrative Order 216-6 to analyze the environmental impacts of a proposed federal action, categorized in this case as 'proposed research activities' related to one another in scope, as the basis of informed decision making.

The scope of the proposed research activities primarily involves obtaining scientific data and information related to reducing sea turtle bycatch during commercial fisheries through the undertaking of specific research activities in captivity and in the field, thereby supporting the recovery of declining sea turtle species worldwide. As all the sea turtle species are listed under the Endangered Species Act, an Environmental Assessment is prepared per the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 *et seq*.), the Council on Environmental Quality's (CEQ) regulations at 40 C.F.R. Section 1508.27 and the NOAA Administrative Order 216-6 (NAO 216-6).

The research activities analyzed in this EA represent the major sea turtle bycatch reduction research components of the PIFSC. Related research activities involving sea turtles have been previously analyzed in the Programmatic Environmental Assessment of the PIFSC's Marine Turtle Research Program (NOAA and NMFS 2006). Proposed research activities outlined and analyzed for environmental impacts in this document include: deployment of satellite archival tags on longline-caught and free swimming turtles and subsequent data analysis to determine long-term movement patterns to assist in the design of time-area fishery closures; biochemical profiling of incidentally-captured sea turtles; research involving the sensory and behavioral biology of sea turtles; and research on the effects of natural chemical and physical repellents on captive sea turtles. This analysis presents information on the anticipated effects to the human environment resulting from the proposed research activities.

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1.0 Purpose and Need for Proposed Action

1.1 Purpose and Need for Proposed Action

The purpose of this environmental assessment (EA) is to evaluate the potential environmental effects as a consequence of proposed research activities (proposed action) involving endangered or threatened sea turtle species. The goal of the proposed research activities is to provide the marine turtle research community, and ultimately longline fisheries, with research data that will assist in reducing sea turtle bycatch in commercial longline fisheries. Permits under Section 10 (a)(1)(A) of the Endangered Species Act (ESA) to 'take' ESA listed species for scientific purposes or to enhance the propagation or survival of the affected species have already been approved to conduct applicable components of the research activities proposed in this document. For research activities that take place outside of United States jurisdiction, the appropriate in-country permits and authorizations have been obtained and approved. The PIFSC has chosen to prepare this EA to evaluate the need for an EIS, to inform the public that environmental considerations have been evaluated, and to assist the agency in planning and decision-making regarding the proposed research activities.

As outlined below, there is a specific need to conduct the proposed research activities in order to reduce the incidence of endangered and protected sea turtle injuries and deaths due to longline fishing and related fishing activities.

At present, all species of sea turtles are categorized by the International Union for Conservation of Nature and Natural Resources (IUCN) (IUCN 2004) as "critically endangered" (hawksbill [*Eretmochelys imbricata*], Kemp's ridley [*Lepidochelys kempii*] and leatherback [*Dermochelys coriacea*]), "endangered" (loggerhead [*Caretta caretta*], olive ridley [*Lepidochelys olivacea*], and green [*Chelonia mydas*]), or "vulnerable" (Australia's flatback turtle [*Natator depressa*]). Under the U.S. Endangered Species Act (ESA), leatherback, hawksbill, Kemp's ridley, the populations of olive ridley turtles nesting in Mexico, and the populations of green turtles in Florida and the Pacific coast of Mexico are listed as endangered; loggerhead turtles, other Pacific populations of olive ridley turtles, and the Hawaii population of green turtles are listed as threatened. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) identifies all sea turtle species excluding the flatback as threatened with extinction, and prohibits the international trade in sea turtles and sea turtle products.

Most sea turtle species are highly migratory, traveling over broad expanses of ocean between nesting and foraging grounds, and often are caught incidentally during commercial foreign and domestic pelagic longline fisheries as bycatch. Often, sea turtles caught are either injured or killed as a result.

A major goal of NOAA's National Marine Fisheries Service (NMFS) is to encourage adoption of more turtle-friendly gear or methods in both domestic and foreign longline fisheries. Thus, research would be designed to perform exploratory sensory and behavioral research on what attracts and deters turtles and to test the effectiveness of alternative fishing gear or fishing methods as they relate to decreasing sea turtle bycatch.

In the March 29, 2001, opinion, National Marine Fisheries Service (NMFS) Conservation Recommendation #1 specifically identified research to reduce or prevent turtle interactions with longline fishing gear:

> “NMFS should research modifications to existing gear that (1) reduce the likelihood of gear interaction s and (2) dramatically reduce the immediate and/or delayed mortality rates of captured turtles (e.g., visual o r acoustic cues, dyed bait, hook type). The goal of any research should be to develop a technology or method, via a robust experimental assessment, which would achieve the above two goals and remain economically and technically feasible for fishermen to implement."

The Final Recovery Plans for the U.S. populations of the loggerhead, leatherback, olive ridley, and green turtles all state that a necessary recovery action for these species is the development of longline fishing techniques that reduce the incidental injury and mortality that occurs in commercial fisheries (NMFS and USFWS 1998a-d). To this end, the proposed experimentation will directly address the goals of NOAA and other agencies aimed at reducing sea turtle bycatch in domestic and foreign fisheries.

All of the individual research activities proposed in this EA are inter-related, and are together intended for the key purpose of reducing the threat of incidental capture of and mortality to sea turtles from longline fisheries by conducting scientific research aimed at gathering valuable data which will aid in devising technologies and strategies in an effort to reduce sea turtle bycatch in domestic and foreign longline fisheries.

NEPA regulations specify that ‘similar actions’ may be analyzed in a single environmental assessment, as specified in section 1508.25 (a) (3): ‘similar actions, which when viewed with other reasonably foreseeable or proposed agency actions, have similarities that provide a basis for evaluating their environmental consequences together, such as common timing or geography. An agency may wish to analyze these actions in the same impact statement. It should do so when the best way to assess adequately the combined impacts of similar actions or reasonable alternatives to such actions is to treat them in a single impact statement.’ As such, this EA will address the individually proposed research activities as ‘similar actions’ having a common purpose and need as outlined above.

1.2 Proposed Research Activities

The following research activities outlined are proposed in an effort to provide the marine turtle research community, and ultimately longline fisheries, with research data that will assist in reducing sea turtle bycatch in commercial longline fisheries. The proposed action (research activities as described) is for the Pacific Islands Fisheries Science Center

(PIFSC) to supervise and conduct scientific research activities and data gathering aimed at reducing sea turtle bycatch in the following four areas:

- Deployment of satellite archival tags on longline-caught and free swimming turtles and subsequent data analysis to determine long-term movement patterns to assist in the design of time-area fishery closures;
- Biochemical profiling of sea turtles incidentally captured in longline fishing gear to determine stress levels and rate of survivability post-capture;
- Research involving the sensory and behavioral biology of sea turtles;
- Research on the effects of natural chemical and physical repellents in captive sea turtles.

Experiments in these specific areas would focus on testing gear or researching methods that have shown promise for reducing sea turtle bycatch or bycatch injury. As described in Section 2.2, typical experiments may involve the use of synthetic shark shapes or scarecrows as deterrents to fishing gear, variations in lightsticks known to attract both target species and turtles to fishing gear, visual sensitivity screening and behavioral assessments of turtles and hatchlings, feeding behavior and biomechanics, the testing of natural pheromone chemical repellents and mesh metals as deterrents to fishing gear, sea turtle tagging, and serological evaluations of incidentally caught sea turtles.

1.3 Background

1.3.1 Current Status of Sea Turtles

All populations of sea turtles are in decline, except for some olive ridley subpopulations, which appear to be increasing, and the Hawaiian green turtle population, which is definitely increasing. Impacts to sea turtles throughout the world are primarily due to the composite effect of human activities which include: the legal harvest and illegal poaching of adults, juveniles, and eggs, incidental capture in coastal and high-seas fisheries as bycatch, loss and degradation of nesting and foraging habitat, and predation on nesting beaches by feral and domestic animals, especially dogs and pigs, and humans. Increased environmental contaminants, such as sewage and industrial discharges, and marine debris, which adversely impact nearshore ecosystems that turtles depend on for food and shelter, including sea grass and coral reef communities, also contribute to the overall declines. In addition to anthropogenic factors, natural threats to the nesting beaches and pelagic-phase turtles such as coastal erosion, seasonal storms, predators, temperature variations, diseases such as fibropapillomatosis and spirochidiasis, and phenomena such as El Niño also affect the survival and recovery of sea turtle populations.

As a result, most sea turtle species are threatened with extinction. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) identifies all sea turtle species excluding the Australian flatback as threatened with extinction, and prohibits the international trade in sea turtles and sea turtle products.

Most sea turtle species are highly migratory, traveling over broad expanses of ocean between nesting and foraging grounds. Their conservation requires international cooperation in alleviating all of the primary threats to their recovery. The proposed action is intended to reduce the threat of capture and injury and mortality to sea turtles from pelagic longline fisheries through exploratory sensory and behavioral research to determine what attracts turtles to fishing gear and experimentation of avoidance strategies to deter turtles from hooking and entanglement, as well as fishing gear modification to eliminate capture of turtles that are attracted to gear.

1.3.2 Longline Fisheries and Effects on Sea Turtles

Highly productive areas of the world's oceans attract sea turtles by their accumulation of forage species. High concentrations of forage species also attract commercially valuable predators such as tunas and swordfish, which ultimately attract the foreign and domestic longline fishing fleets. Pelagic longline fleets range in size from small-scale traditional domestic artisanal, or local non-commercial, fisheries, to small domestic commercial fleets, to modern mechanized industrialized fleets from distant water fishing nations. Target species include tunas such as yellowfin (*Thunnus albacares*), swordfish (*Xiphias gladius)*, other billfishes, mahimahi (*Coryphaena hippurus)*, sharks and others types of fish.

Longlining involves suspending a large mainline from floats at the sea-surface with attached branch lines and baited terminal hooks. The configuration of the gear, including the length of the mainline, the number of branch lines between floats, the maximum depth of branch lines, the size of hooks, the bait, and other characteristics vary with the specific fishery.

However, depending on the target species, longline fisheries may deploy mainlines and hooks at depths ranging from near the surface to up to approximately 400 m. Tracking studies indicate that turtles spend a majority of their time at depths less than 40 m (Polovina et al. 2003, 2004); therefore, even when hooks are intended to fish at depth, they must pass through the near surface waters frequented by sea turtles, potentially attracting sea turtles to the baited hooks. Lewison et al. (2004) estimated that pelagic longline fleets from 40 nations set about 1.4 billion hooks in 2000, an average of about 3.8 million hooks every day. Their summary indicated that more than half (52%) of the hooks were set in the Pacific, while the Atlantic (including the Mediterranean) had 37% of hooks set and the Indian Ocean the remaining 11%.

Turtles may become hooked by biting a baited longline hook or being snagged in passing, or they may become entangled in the line. If the branch line is not long enough to allow the turtle to surface to breathe and the turtle remains suspended under water, it will likely drown. Even turtles hooked or entangled but released alive may subsequently die due to internal injuries and/or secondary infections.

Leatherback and loggerhead turtles are the species most likely to interact with longline gear in mid-ocean because they spend more of their lives in pelagic habitats than other sea turtles, but other species are caught as well (Polovina et al. 2003). In the last two decades in the Pacific, numbers of nesting female leatherback turtles have dropped 95% and numbers of nesting female loggerhead turtles have dropped by about 80% on their primary nesting beaches (Spotila et al. 1996, 2000, Kamezaki et al. 2003, Limpus and Limpus 2003).

In tropical waters, olive ridley turtles are often the dominant turtle species caught by longlines, as they are in many fisheries off the Pacific coast of Latin America (Arauz et al. 2000, Lagarcha et al. 2005) and in the Hawaii longline fishery targeting tuna. Olive ridley turtles are considered the most abundant sea turtle in the world, although it is still listed as threatened under the ESA and the Mexican nesting population is listed as endangered. Although populations of olive ridleys have decreased significantly in the Atlantic Ocean, other aggregations, such as those in the eastern Pacific Ocean, have experienced significant increases in abundance in recent years. Approximately 75% of the olive ridleys taken in the Hawaii in the longline fishery originate in the eastern Pacific Ocean (NMFS 2005). Many of these turtles are caught in the deep-set fishing gear targeting tuna, with the majority dead upon retrieval.

Camiñas and de la Serna (1995) estimated that 200,000-316,000 loggerheads and 50,000-114,000 leatherbacks are captured annually in worldwide fisheries, with 60% of the catch from the Atlantic Ocean, 30% from the Pacific and Indian Oceans, and 10% from the

Mediterranean Sea. Lewison et al. (2004) also attempted a global quantification of the issue and arrived at similar numbers. Of the estimated 1.4 billion hooks set in 2000, Lewison et al. (2004) estimated that 86% of the hooks targeted tunas and 14% targeted swordfish. Turtle bycatch rates from swordfish and tuna fisheries ranged from 0 to 14 loggerheads and 0 to 2.4 leatherbacks per 1,000 hooks set. Atlantic and Mediterranean bycatch rates were higher than those from the Pacific for both turtle species. Extrapolating from documented turtle bycatch rates to total hooks set, the authors estimate that 220,000-250,000 loggerheads and 50,000-60,000 leatherbacks were captured globally in longlines in 2000. Loggerhead captures in the Mediterranean were estimated to total 60,000-80,000, while those in the Pacific were estimated at 30,000 loggerheads, along with 20,000 leatherbacks.

1.4 Scope of this Environmental Assessment

This Environmental Assessment (EA) provides a detailed framework for the sea turtle bycatch reduction research components of the PIFSC, including analysis of potential environmental impacts associated with implementation of the proposed research activities and alternatives.

The proposed research activities are intended to collect scientific data for evaluating new methods with the goal of reducing the bycatch of sea turtles in fisheries in U.S. and foreign fleets. As outlined in Section 4.3 this EA analyzes the potential effects of this research on individual sea turtles and impacts on sea turtle populations, in which adverse impacts are not anticipated due to refined methods and techniques proven over many years to mitigate and reduce any potential harm to the animals. As evaluated in Section 1.5, potential for impacting other marine species, such as marine mammals and fish, is extremely low due to effective mitigation and based on past experience.

Any other site-specific and/or project-specific long term actions with potential environmental considerations that are not included or specifically covered in this EA will need additional appropriate NEPA analysis in a supplement to this EA (40 CFR 1502.9) or a new NEPA document. Any supplement to this EA shall not affect the analysis or decisions in this original EA nor any other proposed research project consistent with this EA unless specifically stated in the supplement.

The scope of this environmental assessment (EA) is necessarily limited to assessment of the potential environmental effects of conducting focused turtle bycatch reduction experiments. It is not intended to and does not address the potential environmental or economic effects of widespread adoption of gear or other operational strategies for reducing turtle bycatch.

Similarly, this EA reviews relevant information with respect to longline fishing methods as they directly relate to sea turtle involvement; however, it does not address the affected environments and environmental consequences of longline fishing and fisheries as a whole.

1.5 Issues Eliminated from Detailed Study

NEPA, CEQ regulations, and NOAA procedures for implementing NEPA specify that an EA should address only those resources or resource areas that are potentially subject to adverse impacts, and that the level of analysis should be commensurate with the anticipated level of environmental impact. Therefore, the following resource areas have not been carried forward for detailed analysis, as potential impacts were considered negligible or non-existent:

- *Archaeological, Social or Cultural Resources.* Implementation of the proposed action would have no effect on the above cultural and social indicators. It would not have a disproportionate effect on low-income or minority populations, nor would it impinge on the religious freedom of any group.

- *Non-Native or Invasive Species.* The proposed action would not contribute to the introduction or spread of non-indigenous or invasive species.

- *Public Health and Safety*. The proposed action is to reduce sea turtle bycatch and as such would have no effect on public health or safety, including that of low-income or minority populations.

- *National Scenic or National Historic Trails, Wild and Scenic Rivers, National Marine Sanctuaries, or National Estuarine Research Reserves.* The proposed actions would not occur within any National Scenic or Historic Trails, Wild and Scenic Rivers, National Marine Sanctuaries, or National Estuarine Research Reserves. In addition, the proposed action does not conflict with any Coastal Zone Management Programs in any state or territory of the United States, nor any marine sanctuaries or other designated areas.

- *Nearshore, Benthic, and Pelagic Habitats*. Methods and gear that would be used relative to this assessment are conducted offshore and do not contact the bottom, thus there are no effects on benthic habitat, including benthic portions of Essential Fish Habitat (EFH) designated under Section 305(b) of the Magnuson Stevens Fishery Conservation and Management Act (Magnuson Stevens Act or MSA).

Despite the geographical diversity of the proposed actions, the nature of the proposed research projects involves removing sea turtles from pelagic habitats for short periods of time for serum sampling, tagging and subsequent release, and the projects would not pose any measurable impact on surrounding environments and habitats. Similarly, vision and behavioral studies on sea turtle nesting beaches would involve short-term work directly with sea turtles and hatchlings, and would not pose any measurable impacts on surrounding environments and habitats.

- *Domestic and Foreign Economic Resources*. Because economic analyses under the National Environmental Policy Act (NEPA) are focused on U.S. economies, principal weight is given to analysis of potential economic effects on domestic rather than foreign fleets participating in the experimental research. In both cases, any effects on the economies of domestic and foreign nations whose longline fleets are cooperating in the research would be extremely minor and primarily positive in nature.

- *Critical Habitats.* It is not anticipated that the research proposed in this EA will take place within any of the critical habitats listed for sea turtles or marine mammals as defined by the ESA and designated by the Secretary of the Interior or Commerce.

- *Marine Mammals and other Marine Species:* The risks of incidentally catching a marine mammal or other marine vertebrate or invertebrate in the nets used to evaluate sensory biology and behavior are considered very slim, and precautions are in place to avoid these interactions entirely. For example, nets are not set out when marine mammals are known to be in the vicinity, nets are immediately pulled from the water if marine mammals are sighted, and any incidentally caught marine mammal or marine vertebrate or invertebrate that is caught is immediately untangled and released back into the water away from the nets to prevent recapture. During 2005, only two rays were incidentally caught in the nets described for the proposed uses at Punta Abreojos in Baja Mexico, and these were released back into the ocean unharmed (Wang, NOAA Fisheries Researcher, *pers. comm*.).

- *Air and Water Quality*. Due to the nature of the proposed actions, there would not be any effects on air or water quality.

- *Geology and Soils*. Due to the nature of the proposed actions, there would not be any effects on geology or soils.

- *World Heritage Sites and Other Unique Areas*: Considered a World Heritage Site, the Las Baulas National Park on the Pacific coast of Costa Rica is one of the world's few remaining sites of significant leatherback turtle nesting activity. It supports the largest nesting colony of leatherback turtles in the Pacific Ocean with a population size of about 800 female turtles nesting per year in non-El Niño years. Protection of turtles and their nests is the responsibility of National Park guards, and conservation projects are aimed in part at understanding sea turtle biology through quality scientific research. Also a World Heritage Site, the Whale Sanctuary of El Vizcaino in Baja Mexico is located in the central part of the peninsula of Baja California, and contains some exceptionally interesting ecosystems. The coastal lagoons of Ojo de Liebre and San Ignacio are important reproduction and wintering sites for the gray whale, harbor seal (*Phoca vitulina*), California sea lion (*Zalophus californianus*), northern elephant seal (*Mirounga angustirostris*) and blue whale (*Balaenoptera musculus*). The lagoons are also frequented by all five species of endangered marine turtles found in the Pacific Basin (Etnoyer et al. 2006).

While two proposed research sites, Estero Coyote at Punta Abreojos, Mexico and nesting beaches at Area de Conservación Guanacaste in Costa Rica occur near or within these expansive designated World Heritage Areas, none of these sites nor their protected species would be adversely impacted by the proposed research activities. In Mexico, nearshore research would not intersect with or impact whales or marine mammals that are protected as part of the Site, as these species occur far offshore from the proposed work. Additionally, nesting beaches in Costa Rica are protected as conservation sites within the National Park and as such are carefully regulated and responsible sea turtle research is encouraged and supported. As shown in Section 4.7 appropriate in-country permits have been obtained to conduct such work in both areas outlined.

2.0 Description of the Proposed Action and Alternatives

2.1 Alternative A: PIFSC Does Not Perform Sea Turtle Bycatch Reduction Research as Proposed (No Action Alternative)

The No Action Alternative would not carry forward the specific sea turtle bycatch reduction field and captive research activities supervised and conducted by PIFSC as proposed and outlined in this EA. Other sea turtle and sea turtle related research activities of the PIFSC would continue as usual including but not limited to basic investigations of the biology, life history, and ecology of sea turtles and their benthic habitats and nesting beaches, population monitoring at nesting beaches, sea turtle stranding and salvage work, research on other fishery bycatch reduction methods, sea turtle health assessments, educational outreach, and population modeling.

2.2 Alternative B: PIFSC Performs Sea Turtle Bycatch Reduction Research through Four Methods as Proposed (Preferred Alternative)

Alternative B (Preferred Alternative) is for the PIFSC to conduct research activities and data gathering aimed at reducing sea turtle bycatch in domestic and foreign commercial longline fisheries in the following four areas:

- Deployment of satellite archival tags on longline-caught and free swimming turtles and subsequent data analysis to determine long-term movement patterns to assist in the design of time-area fishery closures;
- Biochemical profiling of incidentally-captured sea turtles;
- Research involving the sensory and behavioral biology of sea turtles;
- Research on the effects of natural chemical and physical repellents on captive sea turtles.

The experimental design for each of the four primary research activities proposed is further discussed in the subsections immediately below. The Preferred Alternative is to use all four research activities described in this alternative.

2.2.1 Satellite Archival Tagging

The incidental capture of marine turtles by pelagic longline fishing gear occurs worldwide. Most interactions occur with shallow-set gear targeting swordfish, mahimahi or yellowfin tuna, although sea turtles are occasionally caught by deep set (>100 m) longline gear targeting fish of high commercial value fish such as bigeye tuna (*T. obesus*); Ferreira et al. 2001, Polovina et al. 2003). Hard-shelled loggerhead and olive ridley turtles are opportunistic feeders and generally bite baited hooks, whereas leatherback turtles are most often hooked in the flippers or simply become entangled (Witzell 1999), likely as a result of having been drawn into the vicinity of the fishing gear.

Nearly all sea turtles incidentally caught on shallowest gear are alive at retrieval (Witzell 1999). There is, however, the potential for high rates of post-release mortality, especially when turtles are released with hooks or lines remaining in their mouths, throats, gastrointestinal tracts, or flippers, which can lead to infection (Aguilar et al. 1995, Chaloupka et al. 2004). Moreover, it has been suggested that longline interactions may be contributing to the global decline in sea turtle populations (Spotila et al. 2000, Hays et al. 2003). For this reason, understanding and ultimately predicting the ultimate fate of released turtles is of growing importance to marine resource managers worldwide.
We propose the continued use of pop-up satellite archival tags (PSATs) to: a) identify mortality of sea turtles following release from longline fishing gear, and b) to look for indications of the severity of sustained injuries by comparing the vertical and horizontal movements of sea turtles released from longline gear with control turtles. Originally designed to track the movement of large pelagic fish (Lutcavage et al. 1999, Arnold and Dewar 2001), PSATs have also been successfully employed to estimate post-release mortality in pelagic fishes (Arnold and Dewar 2001, Graves et al. 2002), and their use has been specifically recommended to measure post-release mortality of pelagic sea turtles (Chaloupka et al. 2004). PSATs can be programmed to detach and transmit archived data if they reach depths (usually >1200 m) well below dive depths for all species of hard-shelled sea turtles (Lutcavage and Lutz 1997), which is indicative of a mortality or they can be programmed to detach and transmit archived data if they experience no change in depth for 4 consecutive days (e.g. the turtle dies over shallow area such as the continental shelf, or the tag has been shed prematurely and is floating on the surface).

Working in collaboration with local commercial longline fishermen, we propose to continue to deploy PSATs primarily on loggerhead turtles, but also on green sea turtles, olive ridley turtles and hawksbill turtles incidentally caught on fishing gear during cruises in pelagic environments offshore of the State of Catarina in Brazil. The tags consist of a tether and baseplate system (described by Swimmer et al. 2002, 2006) to attach the PSATs. Baseplates attached with epoxy will remain on green sea turtles held in captivity for up to one year with no adverse effects to the animals (Swimmer et al. 2002, 2006). Alternatively, the PSAT tether would be attached to a stainless steel U-bolt that would be placed through 2 holes (approximately 0.4 cm in diameter) drilled in the postcentral scutes as described by Epperly et al. (2002).

We would continue to use pop-off tags from 2 manufacturers. Wildlife Computer (WC) tags record depth, pressure, light level, and temperature (°C) every 60 s, and are programmed to record maximum daily dive depth and to release from the animal 1 year after deployment. Microwave Telemetry (MT) tags are programmed to acquire temperature and pressure (depth) readings every hour and to release from the animal 8 months after deployment.

Research and technical staff are specifically trained to capture and tag turtles according to accepted standards within the sea turtle research community (Eckert et al. 1999) based on efficacy and the experience gained through 34 years of implementation.

2.2.2 Biochemical Profiling

Biochemical profiling of sea turtles captured incidentally to the longline fishery entails drawing blood from turtles that have been captured in longline fishing gear and analyzing the samples in a laboratory for various stress markers, as induced stress on the animal associated with entanglement may result in physiological and behavioral disruptions that could affect survivability of sea turtles post-release from longline gear. Biochemical data obtained from blood samples drawn at the time of capture may yield key information regarding physiological status and the likelihood that sea turtles will ultimately survive a fisheries encounter. This information may be used to guide future fisheries management decisions.

The goal of this study is to measure biochemical parameters indicative of stress, such as heat shock proteins and corticosterone, respiratory and metabolic disruption, such as lactate and ions, and cellular and tissue damage (enzymes) in blood samples obtained from sea turtles incidentally captured in commercial longline fishing operations in pelagic offshore environments off the State of Catarina, Brazil to determine the physiological impact of entanglement in longline gear.

Blood sampling is a widely used technique in both ecological and physiological studies of sea turtles in the laboratory and in their natural environment. Blood samples will be drawn from the cervical sinus of sea turtles using standard techniques employed routinely by NOAA Fisheries staff and other researchers in the field (Owens and Ruiz 1980). A combination of either a needle (21G x 1.5") and syringe (5 - 10 ml draw) or a needle (21G x 1.5") and Vacutainer (5-10 ml draw) will be used to obtain samples. Skin around the region of needle insertion will be cleansed with alcohol swabs prior to taking blood samples.

Blood samples will be drawn immediately after landing the turtle onboard the fishing vessel; the turtle will be released immediately after blood sampling. While on board, the turtle will be kept out of direct sunlight and kept moist with seawater soaked towels. Serological samples will be processed for biochemical markers in a laboratory in North Carolina. Should a turtle be encountered that has a previous injury due to gear hooking or entanglement, the turtle will be taken to a veterinary sea turtle facility at Projecto Tamar, an organization that assists in sea turtle conservation in Brazil, for rehabilitation and subsequent release.

2.2.3 Sensory and Behavioral Biology Research

Because sea turtle bycatch associated with pelagic longline fisheries has been implicated as a contributor to the decline in sea turtle populations (Lewison et al. 2004, Spotila et al. 2000), sensory biology experiments on captive and wild sea turtles are proposed in an effort to: a) understand the visual, olfactory and auditory sensory cues that different sea turtle species use to locate food and objects; b) evaluate methods and strategies that might deter sea turtles from approaching longline fishing gear; and c) characterize sea turtles' approach, manipulation, and biting mechanics. All of the proposed experiments have the same goal: to further understand how sea turtles perceive their surroundings visually and biochemically so that bycatch reduction devices can be developed that are appropriate to prevent capture and mortality of sea turtles in commercial fishing gear. In addition, wild turtles captured incidentally to longline fishing will be fitted with archival satellite tags to determine their migration patterns and seasons for minimizing interactions with longline fisheries.

2.2.3.1 Sea Turtle Spectral Sensitivity – Physiological Responses

Increased bycatch of marine turtles has been linked to the use of chemiluminescent lightsticks employed by fisheries to attract fish. Reducing or eliminating the attractiveness of these lightsticks might be achieved simply by using wavelengths (i.e., colors) or light intensities that do not appeal to marine turtles but are attractive to the target fish species. Therefore, we propose the continuation of a series of studies to determine what light wavelengths sea turtles can detect. Previous studies of sea turtle hatchlings suggest that they have limited color vision and are behaviorally attracted to blue wavelengths (Witherington and Bjorndal 1991, Witherington 1992).

Recent research has employed flicker-photometric electroretinography (ERG) to examine aspects of the visual sensitivity of green and loggerhead sea turtles held in captivity at Sea World, San Diego. In this type of ERG, gross electrical changes are monitored at the corneal surface using a conductive contact-lens electrode while the eye is exposed to rapidly flickering monochromatic light (4-40 Hz). To determine sensitivity, retinal responses to the monochromatic light are summed for a series of approximately 50 presentations. The intensity of the light is then adjusted until it elicits stimulation equal to a preset, unchanging value. The relative sensitivity of the eye at each wavelength tested is thus reflected by the amount of light necessary to obtain the desired level of stimulation. Sensitivity is thereby determined for each individual turtle at 10 nm increments from 400-700 nm. Though the procedure is essentially non-invasive, turtles are given an intra-venous injection of general anesthetic, as well as a topical application of local anesthetic to the cornea to minimize any discomfort. The results of this work have been described in detail in Levenson et al. (2004).

We propose follow-up experiments to further evaluate the spectral sensitivity of leatherback sea turtles using flicker-photometric electroretinography (ERG) as described above. However, because leatherback sea turtles cannot be held in captivity, these experiments have to be performed in the field on a nesting beach where adult females come ashore to lay eggs. The site chosen for this project is Matura Beach in Trinidad, West Indies, one of the largest nesting colonies of leatherback turtles in the world. The lead researcher on this project, Dr. Scott Eckert, has served for more than a decade as the Scientific Advisor for a long-term population monitoring project at Matura Beach, and has a unique history of working effectively with the local community and obtaining necessary permits from the Government. Similar experiments have already been conducted on Matura Beach, Trinidad, West Indies over a two week period in May 2004 where a total of 15 leatherback turtles were evaluated for anesthetization for the project, performed under the direction of Dr. Eckert of the Wider Caribbean Sea Turtle Conservation Network. Initial investigations indicated that sensitivity data was best obtained using 4-12 Hz flicker rates, with four subjects exhibiting peak sensitivity at about 509 nm.

Experimental procedures to be conducted exclusively on nesting female leatherback sea turtles would be performed during the day and at night to determine if there are diurnal changes in spectral sensitivity. Turtles would be approached after the completion of egg laying or on foraging grounds, weighed, and anesthetized with an injectable, partially-reversible anesthetic agent, a combination of metatomidine and ketamine. A topical anesthetic would be applied to the cornea. After anesthetization, a Burian-Allen configuration contact lens electrode is placed against the corneal surface to monitor gross electropotential changes. After experiments are complete, the anesthetic reversal agent is injected and the turtles would be restrained from re-entering the water until sufficiently recovered from anesthesia. Captive leatherback turtles at the University of British Columbia, Canada would also be evaluated using the same methods and techniques.

Because there was a disparity between the ERG results initially obtained using leatherbacks and those from previous studies of green and loggerhead sea turtles, research is proposed to address these differences. Indeed, the development of mitigation measures to reduce the effect on turtles of light attraction devices depends on the resolution of this issue.

2.2.3.2 Sea Turtle Spectral Sensitivity – Behavioral Responses

Predicting why turtles approach baited longlines is critical to reducing the number of sea turtles that are captured during longline fishing. Thus, a more thorough understanding of the behavioral responses related to visual capabilities of different species of sea turtles is necessary to in order to develop fishing gear effective in minimizing the interactions of sea turtles with longline gear.

A common practice in the longline fisheries is to attach light sources near the baited hook on the branch lines to attract fish. Recent experiments with loggerhead turtles have shown that hatchling turtles respond to such lightsticks in a very similar manner (Wang et al. in press) as the juvenile turtles, making hatchling turtles a useful proxy for the juvenile turtles typically caught in the pelagic longline. Conducting experiments with leatherback, olive ridley, green and hawksbill turtle hatchlings would provide an indication of the spectrum and characteristics of light that these turtles are able to sense, specifically ultraviolet (UV) light and polarized light.

Work is proposed at Las Baulas National Park, Guanacaste, Costa Rica in collaboration with an existing long-term turtle monitoring program. All experiments are strictly behavioral and non invasive. Hatchlings turtles would only be held for 2-4 hours before being released at or near the same location they were caught.

Specifically, hatchling sea turtles would be collected from marked nests and from an established hatchery in the vicinity of Playa Grande inside the Las Baulas National Park. Collecting would be supervised and coordinated in conjunction with the trained field staff of Las Baulas National Park. Turtles would be collected during the early evening on the night that they would normally emerge, based on nesting date and local incubation times. Once collected, turtles would be kept in darkened styrofoam containers prior to experiments.

Experiments would utilize similar procedures that have been used previously in published studies of hatchling orientation (e.g., Lohmann 1991, Lohmann and Lohmann 1994, 1996, Lohmann et al. 2001). Briefly, turtles would be tested one at a time in a water-filled circular arena approximately 2 meters in diameter. Each turtle would be placed into a nylon-Lycra harness that encircles the carapace, but does not impede swimming, and tethered to a rotatable lever-arm attached to an electronic tracking unit wired to a laptop computer (Figure 1). Software developed for the tracking system enables continuous monitoring of the direction toward which a turtle swims.

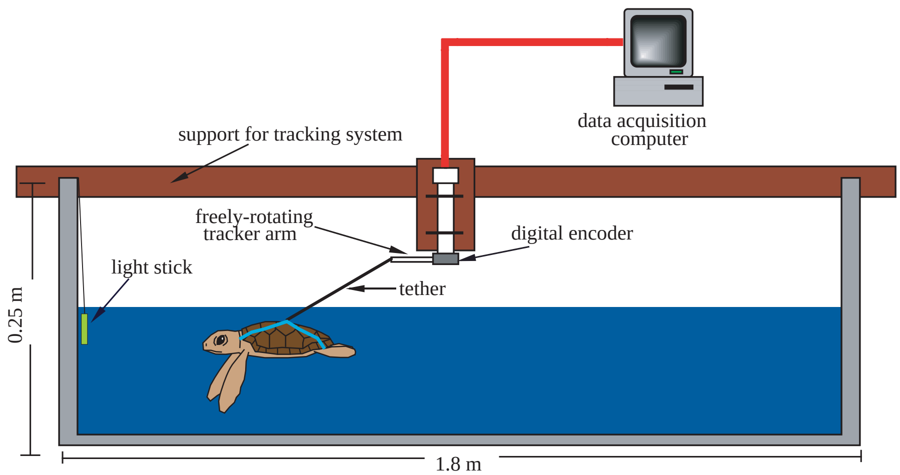

Figure 1. Diagrammatic representation of the arena and tracking system used to monitor the orientation of hatchling turtles. The data acquisition computer records the swimming direction of the turtle. Diagram is not to scale.

To determine if hatchlings are attracted to lightsticks or light-emitting diode (LED) light sources, turtles would be tested in a completely dark arena at night in the presence of an activated lightstick or LED. After a 5-minute adjustment period, the tracking computer would be activated and the orientation of the turtle recorded every 10 seconds over a period of 10 minutes. Mean angles and vector lengths for each turtle would be calculated using all measurements obtained during the 10-minute period of data collection. After testing, hatchling turtles would be released that same night near their capture point, with researchers on the beach to ensure that they reach the ocean without incident.

We plan to test hatchling reactions to: a) unactivated lights (control), b) green lightsticks, c) blue LEDs, d) green LEDs, e) yellow LEDs, and f) UV LEDs. We also plan to conduct trials with polarized light filters. Approximately 20 turtles will be tested under each light condition. A total of 120 turtles for each species will be tested and released.

Hatchling crawling orientation in the presence of different light inputs is also proposed, with experiments utilizing similar procedures that have been used previously in published studies (e.g., Witherington and Bjorndal 1991). Briefly, turtles would be tested one at a time in a modified V-Maze (Figure 2), a V-shaped box with identical arms 100 cm in length. Hatchlings would be placed in a starting box and allowed to crawl down either arm of the maze. At the end of each arm, light sources of equal intensity may be positioned with and without linearly polarizing filters oriented either horizontally or vertically. Hatchling turtles would be evaluated for preference to:

a) horizontally polarized light vs. no polarized light,
b) vertically polarized light vs. no polarized light,
c) horizontally polarized light vs. vertically polarized light, and
d) circular polarized light vs. no polarized light.

Each single trial is expected to last approximately 5 minutes, with 30 turtles tested for each experimental setup. After testing, hatchling turtles would be released that same night, with researchers on the beach to ensure that they reach the ocean without incident. A total of 120 hatchlings of each species will be tested and released.

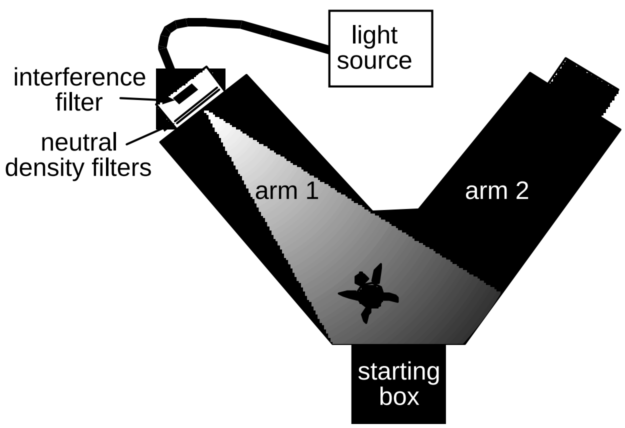

Figure 2. Modified V-Maze for evaluating hatchling crawling orientation with respect to different polarized lights.

Additional studies to identify which colors sea turtles can discriminate from the UV to infrared and which colors are most visible and attractive to sea turtles with varying light intensities and flash frequencies are also proposed using the modified V-maze in an effort to reveal a repellent or unattractive light stimulus or to find a color response that might attract turtles away from baited longlines. Methods used would be similar to those outlined previously in this section.

2.2.3.3 Evaluating the Use of Lightsticks

As mentioned, a common practice in the longline fisheries is to attach light sources near the baited hook on the branch lines to attract fish. These light sources include chemical lightsticks and battery-powered light-emitting diodes (LEDs) known as Electrolumes®. Recent laboratory experiments have shown that lightsticks used in the longline fisheries attract turtles (Wang et al. 2005, in press), suggesting that lightsticks may be one of the cues responsible for bringing turtles into the vicinity of the fishing gear.

Recent laboratory studies have shown that captive reared juvenile turtles are attracted to lightsticks (green, blue, white, etc) used in the longline fisheries (Wang 2005, Wang et al. in press). Recent work has indicated that modifying these lightsticks (e.g. shading the lightsticks, using blinking lights, and using narrow yellow-green wavelengths of light at 540nm – 580nm) decreases their attractiveness to turtles (Wang et al. in press). Building on this work, we propose to develop field-testable shaded and blinking modified lightsticks described below.

Shaded lightsticks. Sea turtles typically occupy the top portion of the water column. Recent work has found that loggerheads spend 75% of the time in the top 5 m of the ocean (Bolten 2003). In contrast, longlines are typically set in deeper water. The Hawaiian shallow-set swordfish fisheries place mainlines on average at a depth of 64 m (Bigelow et al. 2006). By placing shades on top of lightsticks, the amount of light reaching turtles can be reduced, without reducing the amount of light shining downward.

*Blinking lightsticks***.** Recent work has found that lightsticks that turn on and off at different rates have different levels of attraction. When lightsticks are on for 170 milliseconds (ms), 510 ms, or 1020 ms over a 2.4 second (s) period (on for 7.1%, 21%, 42% of the time), turtles are not attracted to them. However, when the lightsticks are on for 2040 ms over a 2.4 s period (on for 84%) the turtles are attracted to the lightsticks. These results suggest that having lights on for 42% of the time over a 2.4 s period, maximizes the amount of time the light will be on and available to attract fish without becoming attractive to the turtle. We plan to develop an electronic battery powered LED lightstick that blinks on and off at this rate to test this hypothesis.

We propose to compare the rates of turtle captures on nets with normal lightsticks and with modified lightsticks. We would conduct experiments in the waters of Estero Coyote near Punta Abreojos in Baja, Mexico on the Pacific coast where there has been an ongoing long-term study examining the population dynamics and distribution of green turtles, loggerheads, hawsbills, and olive ridley sea turtles . Recent exploratory work at this location indicates that there is a very high sea turtle bycatch capture rate and there is a strong team of local fishermen who have experience in capturing marine turtles for a long-term population monitoring program (J. Seminoff, NOAA Fisheries Biologist, *pers. comm*).

We would set two nets of equal size (8m deep x 100m long) in two locations within a shallow estuary near Punta Abreojos. One net would have normal commercially-available lightsticks (LP Electrolumes) placed every 10m along the net (control net). The second net would have modified lightsticks (shaded LP Electrolumes) placed every 10m along the net (experimental net). Experiments would be conducted during the night and nets put out during the neap tides of the 1st quarter moon. Fishermen who participate in local turtle monitoring efforts have indicated that this is time period has the largest catch rates of various turtle species. Preliminary results from exploratory work confirm this anecdotal finding. Comparisons would be made between the catch per unit effort (CPUE) of each net type. Turtles would be released upon capture.

2.2.3.4 Evaluating the Use of Scarecrows

Using predator shapes to startle or frighten off turtles may be another method of reducing the interactions of sea turtles with fishing gear. Preliminary experiments suggest that sea turtles do avoid shark-shaped decoys (Higgins et al. 2005). However, the strategy of using shark shapes would only be useful if they selectively deter turtles and have little effect on the behaviors of targeted fish.

Recent work examining the visual physiology and behavior of sea turtles indicates that sea turtles are able to sense UV light (<400 nm) while many pelagic fish such as mahi-mahi and marlin cannot (Fritsches and Warrant 2005). This suggests that UV light can be used as a selective communication channel to sea turtles. One way of doing this is by using materials that are transparent but absorb light in the UV range. Several types of clear plastics exhibit these properties, including acetate sheets, mylar sheets, and Dupont TedLar film. When these 'clear' plastic sheets are placed in water, they appear to humans and other animals without UV-vision as completely transparent. In contrast, since these plastics absorb UV light, they will appear as dark sheets to animals (e.g. sea turtles) that have UV vision.

By combining the avoidance behavior of turtles to shark shapes with 'clear' UV absorptive material, we can potentially create shark-shaped scarecrows that sea turtles can see but pelagic fishes cannot. We would like to determine whether this would be a useful strategy to reduce turtles' attraction to fishing gear. As a first step, we propose to place shark-shaped silhouettes near nets set during the day to determine their effect on turtle catch per unit effort (CPUE). We propose to compare the rates of turtle captures on nets with shark-shaped silhouettes and nets without shark-shaped silhouettes. We plan to conduct our experiments in the waters near Punta Abreojos in Baja, Mexico on the Pacific coast where there has been a history of relatively high turtle CPUE (J. Seminoff, *pers. comm*.), as well as in Trinidad. We plan to use the same nets (8m depth x 100m length) as in the lightstick experiments, but would conduct the experiments during the daytime. Shark-shaped silhouettes would be placed every 10m along one net (experimental), while the other net would not have shark-shapes attached to it (control). Nets would also be put out during the neap tides of the 1st quarter moon to maximize the potential of turtle captures.

If this method of decreasing turtle CPUE is successful, it may also have several other potential uses. Shark-shaped scarecrows could be placed near the intake pipes of power plants, salt production facilities, and harbors to reduce numbers of incidentally captured turtles. In an effort to test the efficacy of shark shapes in such a setting, we propose the suspension of flexible acrylic shark shapes around and above the water intake structures at the St. Lucie Power Plant in Florida where turtles are incidentally caught daily as they feed and explore. Because of the years of high quality turtle CPUE data available for the plant, it should be possible to identify a measurable effect. In addition, these shark shapes may also be a useful method to deter other animals such as marine mammals from approaching fishing gear or particular areas such as marinas where they can be accidentally injured or killed.

2.2.3.5 Feeding Behavior and Biomechanics and Mouth Model Development

Recent work has examined the potential for sea turtles to swallow different hook sizes and bait types (Stokes et al. 2006), but has not focused on other behavioral and biomechanical factors which lead to increased potential of entanglement and hooking in longline gear. Identifying characteristic features associated with a turtle's approach to baited hooks (e.g. angle of approach, position of flippers), as well as behavioral and biomechanical features associated with feeding (e.g. use of flippers, gulping, chewing, bite force mechanics, feeding kinematics, and jaw-joint mechanics) will be helpful in understanding why turtles may become entangled or hooked in the branchlines.

Developing an ethogram, or catalog of the animal's behavior, will be helpful in designing new fishing gear that could reduce the incidental capture of sea turtles in fisheries.

We propose to characterize sea turtles' approach, manipulation, and biting mechanics of two common longline bait types. The feeding trials would test for behavioral differences in feeding relative to food item (squid vs. mackerel), food and hook size, orientation of food, and placement of food on pseudo-hooks that have been proven to be harmless to turtles. The lateral, frontal, and dorsal aspect of feeding turtles would be videotaped and the footage would be analyzed using motion analysis software program to calculate a kinematic profile, or summary of discrete feeding movements based on variables including maximum gape, maximum time to gape, velocity of strike, angular orientation of head to food, and frequency of strikes. This work would be helpful in examining the effects of using stiffer branchlines or differences in bait threading on turtle hooking and entanglement rates. Work would be performed at both the Bahía de los Angeles Sea Turtle Facility in Mexico and the NOAA Sea Turtle Facility in Galveston, Texas, and would involve the monitoring of turtle feeding behavior in at least four different marine turtle species: loggerhead, olive ridley, green and hawksbill.

Observations would be conducted in a 5m circular arena at the Sea Turtle Facility, with one individual per tank. In addition, the bite force capability of pelagic-stage loggerhead turtles would be assessed at the NOAA Sea Turtle Facility in Galveston, Texas by allowing turtles to bite down on a bite force transducer customized for loggerhead mouth shape and gape. Data would be collected and analyzed over a two-year period of study.

In addition to previous work evaluating number of alternate hook size, type, and offsets to minimize damage to the loggerhead turtles and to minimize hooking during biting or swallowing longline baits, development of a loggerhead mouth model is proposed. Such a model would allow hook configurations that remain dangerous to the turtles to be identified and adjusted prior to deployment. Such a model should reduce takes, reduce the degree of risk that the turtles face, and save money by eliminating costly field testing of hook configurations that are not promising.

To create a functional model, skulls from previously obtained loggerhead turtles will be prepared and fitted with flexible polymer casts of the mouth, including the tongue, Eustachian tubes, and the esophagus (including the papillae of the anterior third of its length). Once a suitable master model is produced, several replacement soft tissue models can be made so that damaged models can be replaced.

The combination of these lines of research will be needed for designing physical and computer models of the head of loggerheads that can be used in future experiments to investigate how these turtles directly interact with the different types of long line fishery hooks themselves. Such information will prove to be important in the next generation of hooks that may further reduce sea turtle bycatch and still target commercial fish.

2.2.4 Repellents

In collaboration with scientists from SharkDefense, LLC and the University of Hawaii, the Pacific Islands Fisheries Science Center proposes to test the use of semiochemicals and inert metals with special characteristics as natural repellents in order to reduce the incidental and unwanted bycatch of sea turtles in longline fisheries operations.

Semiochemicals, often referred to as pheromones, are natural chemical messengers found in the aqueous-phase extract derived from decayed shark tissue that sharks may use to orient, survive and reproduce in their specific environments. Certain trace semiochemicals have the ability to trigger a flight reaction in sharks when properly isolated and extracted. The possible use of semiochemicals as a shark repellent was first proposed by Baldridge (1990) and Rasmussen and Schmidt (1992). In 2001, investigation of these possibilities led chemists to begin qualitative analysis on semiochemical materials using captive sharks. A variety of analytical instruments and techniques were employed to isolate possible semiochemical candidates.

The end product in isolating such compounds is an ethanol/water solution containing the naturally produced semiochemicals. The active components are the catabolism near-end products of butyric decay and are therefore naturally-occuring chemicals from decay of fleshy material (primary and secondary amines, biogenic amines, fatty acids, purines). It is the combination of these compounds that create the selective repellency for sharks and not teleosts (bony fish that are not sea turtle predators). Activity of the semiochemical is improved using chromatography, such as solid-phase extraction, to concentrate the active components. The composition of semiochemicals varies based on the tissue extracted and consists of between ten and a hundred compounds as an aqueous mixture.

None of the solvents and intermediates in this process are cited in: the Clean Water Act, Priority Pollutants, Section 307; Marine Pollutants, per 49CFR Parts 171 and 172; Toxic Release Inventory Chemical, per EPA 260-B-01-001; Hazardous Substances (Superfund), Clean Water Act and can therefore be discharged into waters. Similarly, none of the compounds identified and isolated thus far in the semiochemical extract are considered poisons or toxins to marine life.

Misch metals (German for "mixed") represent a physical 'magnet' potentially capable of repelling sea turtles and other marine life away from longlines. Misch metal is an alloy of lanthanum and cerium, or neodymium and praseodymium, depending on grade. Blocks of these metals are suspended in the water for a short period of time and act similar to a magnet. It is hypothesized that the electromagnetic effect caused by the electropositivy of the metals in conductive seawater creates a physical repellent to marine life sensitive to electromagnetic waves in the water.

We propose to investigate the use of semiochemicals and misch metals as natural sea turtle repellents by testing these compounds on captive turtle behavioral responses. A pilot study conducted in 2004 by Shark Defense, LLC found that one series of semiochemicals were ineffective as sea turtle repellents, but promising results were obtained from initial screening of another series of semiochemicals. In such experiments, captive sea turtles maintained for research purposes at the NOAA Sea Turtle Facility in Galveston, Texas were exposed to the secretion of small quantities (i.e.: 5 to 10 ounces) of different semiochemicals or control substances into the water in a tank and to different misch metals physically suspended in a tank for a short period of time. Additional assays designed to determine the turtle's degree of repulsion and/or attraction to the substances would be employed and data analyzed subsequently. Initial studies would evaluate the behavioral responses of 25 turtles to 5 to 10 ounces of material to determine if the semiochemical and misch metal studies show sufficient promise to be pursued further.

2.2.5 Summary of Proposed Project Locations

Field and captive sea turtle research is proposed at the following locations: Punta Abreojos and Bahia de los Angeles Sea Turtle Facility, Baja Mexico; Brazil; Port St. Lucie, Florida; Matura Beach, Trinidad, West Indies; Guanacaste, Costa Rica; University of British Columbia; and the NOAA Sea Turtle Facility in Galveston, Texas. Additional locations may be added if necessary, provided that the general project activities and predicted impacts remain within the scope of this EA. Table 1 summarizes the proposed project locations and research settings.

Project	Specific Location	Research Settings
I. Satellite Archival Tagging	Brazil	Pelagic, off the State of Catarina, South Brazil
II. Biochemical Profiling/ Serum Collection	Brazil	Pelagic, off the State of Catarina, South Brazil
III. Sensory Biology		
Physiological Responses	Matura Beach, Trinidad and University of British Columbia, Canada	Nesting Beach and approved captive facility
Behavioral Responses	Guanacaste, Costa Rica	Nesting Beach
Use of Lightsticks	Punta Abreojos, Baja, Mexico	Nearshore Estuary
Use of Scarecrows	Punta Abreojos Baja, Mexico, St. Lucie Power Plant, Florida, and Trinidad	Nearshore Estuary and Shallow Nearshore
Feeding Behavior and Biomechanics	Bahía de los Angeles Sea Turtle Facility in Baja, Mexico and NOAA Sea Turtle Facility, Texas	Approved captive facility
IV. Sea Turtle Repellents	NOAA Sea Turtle Facility, Texas	Approved captive facility

Table 1. Summary of proposed project locations.

2.3 Alternative C: Sensory and Behavioral Biology Research *Plus* Satellite Archival Tagging and Biochemical Profiling

Alternative C would involve the proposed experiments investigating sensory and behavioral biology research to assist in the modification of fishing bait and longline gear, the proposed satellite archival tagging experiments, and the proposed biochemical profiling of incidentally captured sea turtles as previously described while eliminating the evaluation of chemical and physical repellents to deter sea turtles. While impacts and risks to sea turtles from the use of semiochemicals are considered to be minimal and extremely temporary, these repellents have not been studied using sea turtles with enough certainty to accurately predict the true risks involved, if any, and for this reason research involving these methods are not included in this alternative.

2.4 Alternatives Eliminated from Detailed Study

Some types of experiments that could be performed will not be considered. These include testing gear modifications or fishing methods that have already been shown to be ineffective or even attractive in terms of turtle bycatch than other available gear or methods. Also eliminated were experiments using gear or methods shown to greatly reduce or impact catch rates of target species unless they involve modifications hypothesized to improve the gears’ performance.

3.0 Description of the Affected Environment

This chapter describes the baseline, existing biological resources that would potentially be affected by the sea turtle bycatch reduction research program of the PIFSC as proposed for consideration in this EA.

3.1 Biological Resources

3.1.1 Sea Turtles

Because the proposed projects considered in this EA are geographically diverse and primarily concern sea turtles and sea turtle interactions, the following section will address background information of all potentially affected sea turtles.

Green turtles, hawksbills, leatherbacks, loggerheads, and olive ridleys are highly migratory or have a highly migratory phase in their life history, which makes them susceptible to incidental capture by longline fisheries. Information on the status of these species is included in this section as well as in the Sea Turtle Recovery Plans (NMFS and USFWS 1991a-b, 1992, 1993, 1998a-e, USFWS and NMFS 1992) and are reviewed extensively in Eckert (1993). The proposed action or its alternatives are not expected to impact populations of the flatback sea turtle, geographically restricted to the waters of Australia, Indonesia and Papua New Guinea (PNG) north of 25ES, and the Kemp's Ridley Turtle found on the Gulf Coast of Mexico and the U.S., and the Atlantic coast of North America as far north as Nova Scotia and Newfoundland. Thus, these species are not considered further in this assessment.

3.1.1.1 Green Turtle

The genus *Chelonia* is composed of two taxonomic units at the population level, the eastern Pacific green turtle (referred to by some as "black turtle," *C. mydas agassizii*), which ranges from Baja California south to Peru and west to the Galapagos Islands, and the nominate *C. m. mydas* in the rest of its range.

The green turtle is a circumglobal species found in tropical seas and, to a lesser extent, in subtropical waters with temperatures above 20EC. The species consists of five main populations: the Pacific Ocean, Atlantic Ocean, Indian Ocean, Caribbean Sea, and Mediterranean Sea that can be further divided into nesting aggregations.

Green turtles are listed as threatened under the ESA, except for breeding populations found in Florida and the Pacific coast of Mexico, which are listed as endangered. The green turtle is categorized as endangered by the IUCN (IUCN 2004), and is listed in Appendix I of CITES, as are all cheloniidae (hard-shelled marine turtles). Seminoff (2002) estimates that the global green turtle population has declined by 34% to 58% over the last three generations (approximately 150 years) although actual declines may be closer to 70% to 80%. Causes for this decline include harvest of eggs, subadults and adults, incidental capture by fisheries, loss of habitat, and disease.

Despite international conservation efforts to protect green turtles in all areas of the world, threats to their survival continue. In the Atlantic and Indian Oceans and the Mediterranean Sea, harvest continues. Egg collection is ongoing at nesting beaches in the eastern Atlantic, western Atlantic and in the Caribbean, while nesting females continue to be killed in the Caribbean, eastern Atlantic and Indian Ocean. High numbers of juveniles and adults are intentionally captured at foraging habitats in the eastern Atlantic, Caribbean, Indian Ocean, and in the Mediterranean (Seminoff 2002). Green turtles are thought to be declining throughout the Pacific Ocean, with the exception of Hawaii, as a direct consequence of an historical combination of overexploitation and habitat loss (Eckert 1993, Seminoff 2002, NMFS and USFWS 1998a).

Green turtles occupy three habitat types: high-energy oceanic beaches, convergence zones in the pelagic habitat, and benthic feeding grounds in relatively shallow, protected waters. Females deposit egg clutches on high energy beaches, usually on islands, where a deep nest cavity can be dug above the high water line. Hatchlings leave the beach and apparently move into convergence zones in the open ocean where they spend an undetermined length of time (Carr 1986b). When turtles reach a carapace length of approximately 20 to 25 cm (8-10 in), they leave the pelagic habitat and enter benthic feeding grounds. Most commonly these foraging habitats are pastures of sea grasses and/or algae, but small green turtles can also be found over coral reefs, worm reefs and rocky bottoms.

Although most green turtles appear to have a nearly exclusively herbivorous diet, consisting primarily of sea grass and algae (Wetherall et al. 1993), those along the east Pacific coast seem to have a more carnivorous diet. Analysis of stomach contents of green turtles found off Peru revealed a large percentage of molluscs and polychaetes, while fish and fish eggs, and jellyfish and commensal amphipods comprised a lesser percentage (Bjorndal 1997).

Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, it is presumed that those in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed several meters in depth (NMFS and USFWS 1998a). The maximum recorded dive depth for an adult green turtle was 110 m (Berkson 1967 *in* Lutcavage and Lutz 1997), while subadults routinely dive 20 m for 9-23 minutes, with a maximum recorded dive of 66 minutes (Brill et al. 1995 *in* Lutcavage and Lutz 1997). Additionally, it is presumed that drift lines or surface current convergences are preferential zones due to increased densities of likely food items (NMFS and USFWS 1998a). Underwater resting sites include coral recesses, the undersides of ledges, and sand bottom areas that are relatively free of strong currents and disturbance from natural predators and humans.

3.1.1.2 Hawksbill Turtle

Hawksbills are recognized by their relatively small size (carapace length less than 95 cm [37 in]), narrow head with tapering “beak,” overlapping scutes, and strongly serrated posterior margin of the carapace.

Hawksbill turtles are circumtropical in distribution, generally occurring from latitudes 30EN to 30ES within the Atlantic, Pacific and Indian Oceans and associated bodies of water (NMFS and USFWS 1998c). The species is widely distributed in the Caribbean Sea and western Atlantic Ocean, with representatives of at least some life history stages regularly occurring in southern Florida and the northern Gulf of Mexico (especially Texas); in the Greater and Lesser Antilles; and along the Central American mainland south to Brazil. Within the United States, hawksbills are most common in Puerto Rico and its associated islands, and in the U.S. Virgin Islands. In the continental U.S., the species is recorded from all the Gulf States and from along the eastern seaboard as far north as Massachusetts, although sightings north of Florida are rare. Hawksbills are observed in Florida with some regularity on the reefs off Palm Beach County, where the warm Gulf Stream current passes close to shore, and in the Florida Keys. Texas is the only other state where hawksbills are sighted with any regularity. Most sightings involve posthatchlings and juveniles. These small turtles are believed to originate from nesting beaches in Mexico.

In the U.S. Pacific, there have been no hawksbill sightings off the west coast. Hawksbills have been observed in the Gulf of California as far as 29EN, throughout the northwestern states of Mexico, and south along the Central and South American coasts to Columbia and Ecuador.

The hawksbill is threatened with extinction throughout its range. It is considered critically endangered by the IUCN (IUCN 2004) and is included in Appendix I of CITES. The hawksbill is protected as an endangered species under the ESA in the U.S. and in certain independent states (Federated States of Micronesia, Republic of the Marshall Islands, Palau) through cooperative agreements.

Hawksbills utilize both low- and high-energy nesting beaches in tropical oceans of the world. Hawksbills will nest on small pocket beaches and, because of their small body size and great agility can traverse fringing reefs that limit access by other species. They exhibit a wide tolerance for nesting substrate type. Visual evidence of hawksbill nesting is the least obvious among the sea turtle species, because hawksbills often select remote pocket beaches with little exposed sand to leave traces of revealing crawl marks. Nests are typically placed under vegetation.

Throughout their range, hawksbills typically nest at low densities; aggregations consist of a few dozen, at most a few hundred individuals. Within U.S. jurisdiction in the Caribbean Sea, nesting occurs principally on beaches in Puerto Rico and the U.S. Virgin Islands. Nesting also occurs on other beaches of St. Croix, Culebra Island, Vieques Island, mainland Puerto Rico, St. John, and St. Thomas. Within the continental United States, nesting is restricted to the southeastern coast of Florida and the Florida Keys (Meylan 1992). The largest remaining concentrations of nesting hawksbills in the Pacific occur on remote oceanic islands of Australia (Torres Strait) and the Indian Ocean (Republic of the Seychelles).

Hawksbills utilize different habitats at different stages of their life cycle. Posthatchling hawksbills occupy the pelagic environment, taking shelter in weedlines that accumulate at convergence points. Hawksbills reenter coastal waters when they reach approximately 20-25 cm carapace length. Hawksbills have a relatively unique diet of sponges (Meylan 1985, 1988). Coral reefs are widely recognized as the resident foraging habitat of juveniles, subadults and adults. The ledges and caves of the reef provide shelter for resting both during the day and night. Hawksbills are also found around rocky outcrops and high energy shoals, which are also optimum sites for sponge growth. Hawksbills are also known to inhabit mangrove-fringed bays and estuaries, particularly along the eastern shore of continents where coral reefs are absent.

As a hawksbill turtle grows from a juvenile to an adult, data suggest that the turtle switches foraging behaviors from pelagic surface feeding to benthic reef feeding (Limpus 1992). As with other sea turtles, hawksbills will make long reproductive migrations between foraging and nesting areas (Meylan 1999), but otherwise they remain within coastal reef habitats.

Anecdotal observations throughout Micronesia, from across the Pacific, and from other tropical oceans of the world are in near total agreement that current stock sizes are significantly below historical numbers. Although quantitative historical records are few, dramatic reductions in numbers of nesting and foraging hawksbills have apparently occurred in Micronesia (Johannes 1986, Pritchard 1982b) and Pacific Mexico just south of California (Cliffton et al. 1982) since World War II, largely because of increased access to remote nesting beaches by indigenous fishermen equipped with spear guns, outboard motors, SCUBA, and other high-tech fishing gear (Johannes 1986, Pritchard 1982). Market pressures from Asia, sustained by a vast fleet of Taiwanese and other fishing vessels of various national origins, are overwhelming the existing stocks. Most important of all, hawksbills are threatened by a pervasive tortoiseshell trade, which continues particularly in southeast Asia and Indonesia even though the once lucrative Japanese markets were closed in 1994 (NMFS and USFWS 1998c).

3.1.1.3 Leatherback Turtle

The leatherback turtle is the largest, deepest diving and most pelagic of the marine turtles. Adults can reach 8 ft (2.4 m) in length and 2,000 pounds (907 kg) in weight. Its shell is composed of a mosaic of small bones covered by firm, rubbery skin with seven longitudinal ridges or keels.

Leatherbacks have the most extensive range of any living reptile and have been reported circumglobally from latitudes 71EN to 42ES in the Pacific and in all other major oceans (NMFS and USFWS 1998b). Except for nesting, leatherbacks lead a completely pelagic existence, foraging widely in temperate waters. The evidence currently available from tag returns and strandings in the western Atlantic suggests that adults engage in routine migrations between boreal, temperate and tropical waters, presumably to optimize both foraging and nesting opportunities (Bleakney 1965, Pritchard 1976, Lazell 1980, Rodin and Schoelkopf 1982, Boulon et al. 1988). Typically, leatherbacks are found in convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Duron 1978, Eckert 1998, 1999, Morreale et al. 1996, Shoop and Kenney 1992).

The species is divided into four main populations in the Pacific, Atlantic, and Indian Oceans, and the Caribbean Sea. Leatherbacks also occur in the Mediterranean Sea, although they are not known to nest there.

The leatherback turtle is listed as endangered under the ESA, and critically endangered in the IUCN Red List (IUCN 2004). Leatherback populations have been severely reduced world-wide. In 1980, the leatherback population was estimated at approximately 115,000 (adult females) globally (Pritchard 1982). By 1995, this global population of adult females had declined to 34,500 (Spotila et al. 1996). Increases in the number of nesting females have been noted at some sites in the Atlantic, but these are far outweighed by local extirpations, especially of island populations, and the demise of once large populations throughout the Pacific, such as in Malaysia and Mexico. The decline can be attributed to many factors, including fisheries interactions, direct harvest, egg collection, and degradation of habitat. On some beaches, nearly 100% of the eggs are harvested.

The diet of the leatherback turtle generally consists of cnidarians (i.e., medusae and siphonophores) in the pelagic environment (for a review see Bjorndal 1997).

3.1.1.4 Loggerhead Turtle

The loggerhead turtle is listed as a threatened species under the ESA. It is also classified as endangered in the IUCN Red List (IUCN 2004) and is listed in Appendix I of CITES, as are all cheloniidae (hard-shelled marine turtles). The greatest threats are loss of nesting habitat due to coastal development, predation of nests, and human disturbances (such as coastal lighting and housing developments) that cause disorientation during the emergence of hatchlings. Other major threats include incidental capture in shrimp trawling and pollution. Shrimping is thought to have played a significant role in population declines.

Loggerheads are circumglobal, inhabiting continental shelves, bays, estuaries and lagoons in the temperate, subtropical, and tropical waters of the Atlantic, Pacific and Indian Oceans (Dodd 1990). Major nesting grounds are generally located in warm temperate and subtropical regions, generally north of 25EN or south of 25ES latitude (NMFS and USFWS 1998c), with some scattered nesting in the tropics. The largest loggerhead nesting colonies in the world are found at Masirah Island, Oman, and along the Atlantic coast of Florida (Groombridge 1982). An estimated 30,000 loggerheads nest on Masirah Island each year (Ross and Barwani 1982), while an estimated 14,150 nest annually on the beaches of Florida (Murphy and Hopkins 1984, Ehrhart 1989). Loggerhead nesting in the Pacific basin is restricted to the western and southern region, primarily Japan and Australia. In the western Pacific the only major nesting beaches are in the southern part of Japan (Dodd 1988). Nesting also takes place in Yucatan, Mexico, Bahia, Brazil and in the Mediterranean Sea. Upon reaching maturity, adult females migrate long distances from resident foraging grounds to their preferred nesting beaches.

After leaving the beach, hatchlings apparently swim directly offshore and eventually become associated with *Sargassum* and/or debris in pelagic drift lines that result from current convergences (Carr 1986a, 1986b, 1987). The evidence suggests that when post-hatchlings become a part of the *Sargassum* raft community they remain there as juveniles, riding current gyres for several years and growing to 40 to 50 cm straight carapace length (SCL). At that point they abandon the pelagic habitat, migrate to the near-shore and estuarine waters along continental margins and utilize those areas as the developmental habitat for the subadult stage. Both juvenile and subadult loggerheads feed on pelagic crustaceans, mollusks, fish, and algae.

3.1.1.5 Olive Ridley Turtle

The olive ridley is one of the smallest living sea turtles (carapace length usually between 60 and 70 cm [24-28 in] and rarely weighing over 50 kg [110 lb]) (NMFS and USFWS 1998d). Under the ESA, the olive ridley turtle is listed as threatened in the Pacific, except for the Mexican nesting population, which is listed as endangered, primarily because of over-harvesting of females and eggs. It is listed as endangered in the IUCN Red List (IUCN 2004), and is listed in Appendix I of CITES, as are all cheloniidae (hard-shelled marine turtles).

The olive ridley sea turtle is widely regarded as the most abundant sea turtle in the world (Carr 1972, Zwinenberg 1976). Until recent historical times and the advent of modern commercial exploitation of sea turtles, the olive ridley was superabundant in the eastern Pacific, undoubtedly outnumbering all other sea turtle species combined in the area. Cliffton et al. (1982) estimated that a minimum of 10,000,000 olive ridleys swam in the seas off Pacific Mexico before the recent era of exploitation.

The olive ridley turtle is omnivorous and identified prey include a variety of benthic and pelagic prey items such as shrimp, jellyfish, crabs, snails, and fish, as well as algae and sea grass (Marquez 1990).

Preferred nesting areas occur along continental margins and, rarely, on oceanic islands. The largest nesting aggregation in the world occurs in the Indian Ocean along the northeast coast of India (Orissa), where in 1991 over 600,000 turtles nested in a single week (Mrosovsky 1993). The second most important nesting area occurs in the eastern Pacific, along the west coast of Mexico and Central America. Elsewhere, olive ridleys nest in much smaller numbers including along the Atlantic coast of South America and western Africa, as well as in the western Pacific and Indian Oceans (Sternberg 1981, Groombridge 1982, Carr and Carr 1991). In the eastern Pacific, the largest nesting concentrations occur in southern Mexico and northern Costa Rica, with stragglers nesting as far north as southern Baja California (Fritts et al. 1982) and as far south as Peru (Brown and Brown 1982).

4.0 Environmental Consequences

4.1 Introduction

Due to the conservation-oriented nature of the proposed research, researchers and staff members are dedicated to minimizing the environmental impacts of their work in the field. Precautions are in place and extra care is taken to protect against the possibility of nets, lightsticks, scarecrow shapes, and other gear becoming marine debris or pollutants. Additionally, the PIFSC and contracted researchers are careful to ensure compliance with all state, Territorial, Federal and foreign (country-specific) regulations and permit requirements regarding protected species research including ESA Section 10(a)(1)(A) permits, and Institutional Animal Care and Use Committee (IACUC) approvals have been obtained for field and captive research, as described in section 4.7 of this document.

Direct and indirect environmental impacts will be considered together and outlined for each alternative in the following subsections.

4.2 Alternative A: PIFSC Does Not Perform Sea Turtle Bycatch Reduction Research as Proposed (No Action Alternative)

The No Action Alternative would not carry forward the PIFSC's specific sea turtle bycatch captive and field research activities as proposed and outlined in this EA, although other research activities of the PIFSC would carry on as usual. Under this alternative there would be no direct impacts to biological resources. In reality, however, the domestic and foreign longline fisheries would continue to operate and large numbers of all species of sea turtles would likely continue to be taken as bycatch without the benefit of further research data and methods. This has the potential to result in continued significant adverse cumulative impacts on protected sea turtle species. The research proposed in this EA has the potential to reduce, but not likely eliminate these significant adverse impacts on protected sea turtle species.

4.3 Alternative B (Preferred Alternative): PIFSC Performs Sea Turtle Bycatch Reduction Research through Four Methods as Proposed

4.3.1 Biological Impacts on Sea Turtles

Table 2 provides an estimate of the number and species of turtles that may be involved in implementation of each research project and the proposed project duration.

Project	Project Duration	Approximate # of Turtles Evaluated	Turtle Species Potentially Affected	Expected # of Turtle Mortalities
I. Satellite Archival Tagging	5 years	50 LH, 25 OR, 10 GR, 10 LB, 10 HB	*LH, LB, OR, GR, HB	0
II. Biochemical Profiling Serum Collection	1 year	30 total	LH, OR, GR, HB	0
III. Sensory Biology				
Physiological Responses	3 years	15 total	LB	0
Behavioral Responses	5 years	240 each	*LB, *OR, GR, HB	0
Use of Lightsticks	5 years	150 total	LH, OR, GR	0
Use of Scarecrows	5 years	150 total	LH, OR, GR, LB	0
Feeding Behavior and Biomechanics	5 years	50 total	LH, OR, GR, HB	0
IV. Sea Turtle Repellents	3 years	25 total	LH, OR, GR, HB	0

Table 2. Estimated number and species of turtles to be evaluated during proposed projects, project durations, and expected turtle mortalities associated with proposed research activities. Key: LB = leatherback, OR = olive ridley, GR = green, LH = loggerhead, HB = hawksbill, * = primary target

The proposed research ranges from non-invasive behavioral studies to collecting blood samples and anesthetizing sea turtles both in the field and in captivity. Impacts on sea turtles for various proposed techniques are listed in order of increasing level of human-turtle interaction. Standard operating procedures are specifically designed to minimize the impacts of these research techniques on turtles and the marine environment.

4.3.1.1 Impacts of handling live adult sea turtles

Handling live sea turtles that have been stranded, captured incidental to longline fisheries, and held in captivity is an essential component in all of the proposed research methods. Uninjured sea turtles that are lightly entangled in fishing gear will be disentangled and released on site. Injured turtles that are captured by trained staff and collaborators may be transported to a facility for diagnosis and treatment by a licensed veterinarian. Whenever possible, turtles are rehabilitated and ultimately released back into their natural environment.

As with any marine research and monitoring program, there is a possibility that captured turtles could experience adverse impacts from capture, ranging from near drowning to drowning by entanglement. Although these are not expected events, mitigation measures to minimize the potential for adverse impacts are in place, and include nets being constantly monitored when in the water and turtles immediately retrieved from the net if encountered (Ehrhart and Ogren 1999). Additionally, several field personnel are in the water during all capture activities in shallow water (hand capture and tangle netting) to ensure that stress to the animal is minimized during capture by passive restraint during hand capture and immediate removal from the net. Sensory biology studies in Baja

Mexico would utilize nets that are specifically designed to capture turtles in that they allow the turtles to surface for air in order to breathe if caught. If a turtle is encountered during capture activities in a comatose state, resuscitation is attempted. Handling time is minimized to reduce the potential for additional stress. Turtles are only handled for the amount of time necessary to complete sampling, measuring, examination, and/or tagging. Data from 135 previously tagged and released turtles from 1982 through February 2006 showed that no tagged turtles found stranded were determined to have died from capture-related activities (NOAA and NMFS 2006). Therefore, no injury or mortality is predicted to occur from capturing, handling, tagging, or sampling during any of the proposed research activities, and measures are in place to minimize the risk to the animals.

While turtle mortalities are not expected as a result of any of the proposed research actions, an additional safety mitigation and experimental design evaluation measure is in place such that should up to two turtle mortalities occur while a research activity is being conducted, all operations involving that activity would be immediately suspended pending review of the methods and procedures. While rare, single animal mortality may occur coincidental to, but not directly resulting from, the research activity due to prior individual injury, disease, or other condition(s) unrelated to the research activity. However, in the unlikely event that a second mortality should occur during the course of the proposed research activity, the experimentation would be halted to verify that experimental design is not a contributing factor.

4.3.1.2 Impacts of non-invasive behavioral studies using adults and hatchlings

Hatchling turtle work in the field is conducted with animals that are leaving a natural nest or with hatchlings from specifically designated hatcheries. Turtles will be handled as described above and studied for approximately two to four hours before being released at the site of capture well before sunrise. Staff and observers ensure that the hatchlings enter the surf unimpeded by any predators or any light cues that may misdirect them on their beach crawl. Related behavioral work has been conducted for the last 40 years with no impact on adult turtles or hatchlings (Avens and Lohmann 2003, 2004, Lohmann and Lohmann 2003, Lohmann 1991, Wyneken et al. 1990).

4.3.1.3 Impacts of natural physical and chemical repellents on captive turtles

The National Marine Fisheries Service (NMFS) Sea Turtle Facility, part of the NOAA/NMFS Galveston Laboratory, is a U.S. Federal Government (U.S. Department of Commerce) Research Facility dedicated to rearing threatened and endangered sea turtles in captivity. It also serves as a Sea Turtle Rehabilitation Center and Sea Turtle Hospital. Approximately 600 sea turtles are reared and rehabilitated in captivity at this facility each year as part of National and International Sea Turtle Recovery efforts and programs which are required by the U.S. Endangered Species Act. Rehabilitated and reared sea turtles are subsequently released into the Gulf of Mexico. As a research facility, the facility routinely assists in developing and testing new tagging methods, participates in studies involving sea turtle growth and feeding, and uses captive reared sea turtles to test experimental fishing gear designed specifically to prevent sea turtles from drowning in fish trawls and becoming entangled or hooked in longline fishing gear. Since 1978, almost 24,000 Kemp's ridleys and 1,500 loggerheads have been reared, tagged, and released from the facility (NOAA Fisheries 2006).

The non-invasive use of a physical repellent such as a misch metal 'magnet' to deter turtles from fishing gear poses no harm to the turtles, as it uses an electromagnetic effect as a deterrent. Semiochemicals are biodegradable byproducts of decaying shark or other animal tissue. They are naturally occurring primary and secondary amines, biogenic amines, fatty acids, purines concentrated in an aqueous ethanol/water solution. Chronic studies on captive yellowfin tuna and Cobia (*R. canadum)* following incubation with and ingestion of semiochemicals showed no adverse reaction or fatalities five days after exposure (Eric Stroud, Shark Defense LLC chemist, *pers. comm*.). While potential effects on sea turtles have not been directly characterized, previous studies exposing sharks and bony fishes to semiochemicals suggest that small quantities of such natural products would have no measurable impacts, including bioaccumulation, on captive sea turtle individuals. As such, we do no anticipate any adverse impacts to sea turtles as a result of this research.

4.3.1.4 Impacts of invasive procedures such as blood sampling, tagging, and anesthetizing

For a complete understanding of sea turtle population dynamics and life history, it is necessary to identify individuals and obtain biological samples for biochemical evaluation. Turtles are tagged with pop-up satellite archival tags (PSATs) using standard techniques (Swimmer et al. 2002, 2006); blood samples are taken using a medical grade needle and syringe (Bolten 1999, Owens 1999). All methods used are performed by trained personnel and have been peer-reviewed and used by sea turtle researchers worldwide. Blood sampling will not be taken from leatherbacks, as observers are not trained to do so. The PIFSC does not perform unnecessary sampling on sick or injured animals unless a veterinarian determines the animal is sufficiently healthy for samples to be taken. No mortality or adverse effects to turtles are expected from tagging or blood sampling.

The attachment of a radio transmitter (i.e., satellite tags) to the shell of a female sea turtle may appear to be obstructive to mating; however, this has been documented not to be the case. Females with satellite tags attached to their shell prior to the nesting season have been observed nesting, and examination of the nests after hatching indicated that successful mating/fertilization had occurred (NOAA and NMFS 2006). Additionally, transmitters continue to decrease in size as technology advances. The transmitters available for use today weigh approximately 0.1 – 0.2 kg and measure 6.5 cm x 3.5 cm x 2.5 cm. The small size of the transmitters reduces the likelihood that the animals' ability to mate or swim will be adversely affected. PSAT tags have been shown to stay attached to the animal for up to one year without any adverse effects being observed (Swimmer et al. 2002 and 2006). A programmatic environmental assessment for the Marine Turtle

Research Program at the PIFSC reaches the same conclusions, that satellite tagging poses no harm or threat to sea turtles (NOAA and NMFS 2006).

Research involving rapid flicker electroretinography (ERG) is essentially non-invasive; however, turtles are given an intravenous injection of general anesthetic as well as a topical application of local anesthetic to the cornea to minimize any discomfort. Turtles on a nesting beach would be approached after the completion of egg laying, weighed, and anesthetized by trained staff with an injectable, partially reversible anesthetic agent, a combination of metatomidine and ketamine. After the experiments are completed, the effects of the anesthesia are reversed using atapamazole and turtles are held from re-entering the water until they are fully recovered from the anesthesia. In previous studies, full recovery and release was achieved without incident (Levenson et al. 2004, Eckert et al. 2004). No short and long term effects from properly administered anesthesia would occur.

4.4 Alternative C: Sensory Biology Research *Plus* Satellite Archival Tagging and Biochemical Profiling

Biological impacts for activities related to sensory biology research, satellite archival tagging and biochemical profiling are outlined in section 4.3. Alternative C eliminates the possibility of using natural chemical and physical repellents on captive sea turtles. While impacts and risks to sea turtles are considered to be minimal and extremely temporary, they have not been studied extensively and as such it is difficult to accurately predict the true risks involved, if any.

4.5 Cumulative Impacts

Though difficult to accurately quantify, the incremental impact of the effects of the PIFSC's sea turtle bycatch reduction research when added to other past, present, and reasonably foreseeable future actions is likely to be positive in nature. As detailed previously, the direct and indirect environmental consequences of the proposed research are expected to be minimal, as research design, methodologies, and standard operating procedures for working with endangered species in sensitive habitats are specifically formulated to minimize any negative impacts on the environment and sea turtles in particular.

With respect to field research activities, as discussed in Chapters 2 and 4, research designs, research approaches, and standard operating research procedures are crafted to minimize the impact on the environment and turtles in particular. Chapter 4 provides details on potential environmental impacts that could result from implementation of the research on sea turtles, as Chapter 1 outlines the resources that would not be affected at all. Chief among these are risks of adverse impacts to sea turtles from invasive research procedures and potential for injury or mortality during capture or handling. However, as outlined in Chapter 4, no impacts would occur to individual sea turtles during any of the research activities.

The proposed research methods are likely to have net cumulative effects that are positive in that they: a) help to support current sea turtle monitoring programs in various parts of the world, b) contribute to foreign economies by purchasing supplies and hiring fisherman and observers in areas that are often economically depressed, c) establish community outreach programs and positive partnerships with foreign governmental agencies to encourage a sense of environmental stewardship, and d) are highly likely to develop into usable strategies to help reduce sea turtle interactions with fishing gear.

The research supports ESA mandates for the conservation and recovery of sea turtles. The role of the proposed research does not include making management decisions that may affect population recovery. Rather, the research and monitoring activities obtain scientific information in support of achieving the biological recovery and sound management of sea turtle populations worldwide.

The goal of reducing sea turtle bycatch is intertwined with unpredictable ongoing activities in the environment such as longline fishing, natural predation, and other forces that may influence affected ecosystems, all of which have unquantifiable influences and impacts on achieving such a goal. However, cooperation with U.S. and international regulatory agencies also aiming to reduce sea turtle bycatch and increase sea turtle stocks worldwide through fishing regulations, increased protection and awareness, anti-poaching laws, and more increases the likelihood that cumulative effects from these sources will be influential, as opposed to adverse, in the conservation of sea turtle species and habitats worldwide.

4.6 Summary of Impacts by Alternative

Table 3 provides a summary of sea turtle research techniques and methods potentially associated with each research project.

	Handling	Capture	Tagging	Blood Sampling	Anesthetizing	Use of Repellents
Alternative A (No Action)						
Alternative B (Preferred)						
I. Satellite Archival Tagging	X	X	X			
II. Biochemical Profiling	X	X		X		
III. Sensory Biology						
Physiological Responses	X	X			X	
Behavioral Responses	X	X				
Use of Lightsticks	X					
Use of Scarecrows	X					
Feeding Behavior and Biomechanics	X					
IV. Sea Turtle Repellents	X					X
Alternative C						
Methods I, II, and III	X	X	X	X	X	

Table 3. Sea turtle research techniques and methods potentially associated with each research project.

Table 4 summarizes and compares the potential impacts of all the alternatives. Alternative A, the No Action Alternative, would have no direct, indirect, or cumulative impacts on most resources; however, its implementation has potentially significant negative impacts on sea turtle populations over time. Of the action alternatives B and C, no impacts are expected on benthic and pelagic habitats, including essential fish habitat (EFH), or critical habitats. Potentially affected resources include sea turtle individuals and populations, which in all cases have potentially significantly positive impacts. Alternative B (Preferred Alternative) employs the use of semiochemicals in captive environments, the impacts of which on sea turtle individuals are expected to be negligible based on studies done in sharks and bony fishes. If this method were proven to be effective in a research setting as proposed, implementation of such a deterrent may have positive impacts on sea turtle populations over time.

Environmental Resource	Alternative								
	A (No Action)			B (Preferred)			C		
	D	I	C	D	I	C	D	I	C
Sea Turtles	o	o	--	o	+	+	o	+	+
Marine Mammals and Other Species	o	o	o	o	o	o	o	o	o

Table 4. Summary of the potential direct (D), indirect (I), and cumulative (C) impacts by alternative. Key: + = highly positive impact; o = no impact; -- = highly negative; ? = unknown.

4.7 Permit Requirements

The PIFSC and contracted researchers are careful to ensure compliance with all state, Territorial, Federal and foreign (country-specific) regulations and permit requirements regarding protected species research.

The PIFSC is covered under several permits authorizing scientific research using captive sea turtles at the NOAA facility in Galveston, Texas, namely: Florida Fish and Wildlife Conservation Commission permit (FWC Marine Turtle Permit TP#015, expires 1-31-2008); Texas Parks and Wildlife Department permit (TPWD, SPR-0390-038, expires 3-14-2009); and U.S. Fish and Wildlife Service permit (USFWS, TE67637904, expires 9-30-2009), which is a Section 10 (a)(1)(A) permit authorizing sea turtle takes and scientific research under the Endangered Species Act (ESA), approved through NOAA's Southeast Fisheries Science Center (SEFSC) for proposed research to be carried out at the NOAA facility in Galveston. ESA 50 CFR 222.310 for threatened and endangered species covers the federal research that opportunistically samples stranded or incidentally captured animals. Institutional Animal Care and Use Committee (IACUC) approvals have been obtained for both field and captive research through the universities involved cooperatively with the research. The Biological Opinions for the permits listed above concluded a "no jeopardy determination" regarding listed sea turtle species and designated critical habitats.

While mortalities due to the proposed research activities are not expected, the above permits authorize euthanasia under the direction of a veterinarian if an individual animal's recuperation is unlikely, if illness or injury is terminal or untreatable, if an illness is communicable and likely to pose a threat to wild or captive populations, or if a specimen's wounds would preclude survival in the wild or a self-maintaining life in captivity.

Jurisdiction under the ESA for sea turtle research extends up to the territorial limits of another county, such that any research conducted on foreign nesting beaches or offshore within that country's territorial waters is not subject to the provisions of the ESA and thus a US ESA permit is not required for those research activities. Table 5 outlines the permits that have been approved for the proposed research activities. Note that where permits are not required under the ESA, in-country laws and regulations are upheld, and approval for proposed research has been granted.

Project	Specific Location	Permits
I. Satellite Archival Tagging	Brazil	None required under the ESA
II. Biochemical Profiling/ Serum Collection	Brazil	None required under the ESA
III. Sensory Biology		
Physiological Responses	Matura Beach, Trinidad and University of British Columbia, Canada	Permitted by national legislation of Trinidad and Tobago; IACUC permit
Behavioral Responses	Guanacaste, Costa Rica	IACUC permit
Use of Lightsticks	Punta Abreojos, Baja, Mexico	None required under the ESA
Use of Scarecrows	Punta Abreojos Baja, Mexico, St. Lucie Power Plant, Florida, and Trinidad	None required under the ESA; IACUC permit; Florida Fish and Wildlife FWC Marine Turtle Permit TP#015
Feeding Behavior and Biomechanics	Bahía de los Angeles Sea Turtle Facility in Baja, Mexico and NOAA Sea Turtle Facility, Texas	CONANP (Mexican Government Permit); IACUC permit; see below for listing of permits associated with the NOAA facility in Texas
IV. Sea Turtle Repellents	NOAA Sea Turtle Facility, Texas	Florida Fish and Wildlife FWC Marine Turtle Permit TP#015; Texas Parks and Wildlife Department SPR-0390-038; US Fish and Wildlife Service TE676379-4; ESA Section 10(a)(1)(A) permit through the SEFSC.

Table 5. Permits in place for proposed research activities.

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